ANOTHER METEORITE WITH A COMPLEX EXPOSURE HISTORY: JaH 073 L. Huber[1], B. Hofmann[2], E. Gnos[3], K.C. Welten[4], I. Leya[1]. [1]Physikalisches Institut, University of Bern, Switzerland, [2]Naturhistorisches Museum Bern, Switzerland, [3]Institut für Geologie, University of Bern, Switzerland, [4]Space Sciences Laboratory, University of California, Berkeley, California 94720-7450,USA. liliane.huber@space.unibe.ch

Introduction: Large stony meteorites are relatively rare because (in contrast to iron meteorites) they fragment during atmospheric entry, producing large meteorite showers. Interestingly, many of the large chondrites, such as Bur Gheluai, Gold Basin, Jilin, and Tsarev, appear to have complex exposure histories with a first-stage exposure on the parent body [1]. The question is, whether a complex exposure history is simply more easily detected in large objects (due to multi-nuclide studies on various aliquots) or whether large objects are really more likely experience a complex exposure history [1].

In order to check whether the observation of complex exposure histories for large objects also holds for the L6 chondrite JaH 073 we analyzed various samples from this extremely well documented strewnfield [2] and also probed the main mass (~55 kg) of this meteorite. From JaH 073 more than 3400 fragments scattered in an area of about 60 km^2 were found. The total mass is approximately 550 kg, whereas the biggest fragment is about 55 kg [2]. The terrestrial age of JaH 073 has been determined to be about 18 ka [2].

Experimental: The experimental setup follows the procedure described in [3]. System blanks were determined by analyzing ~20 mg of Ni foil using the same heating and extraction procedure as for the samples. The blanks, which are usually below 0.1%, 0.5%, and 0.8% for He, Ne, and Ar, respectively, add only negligible uncertainties to the measured isotope concentrations. Cosmogenic ^{21,22}Ne and ^{36,38}Ar concentrations were determined from measured gas amounts by subtracting a trapped component, i.e., atmospheric air contamination, using a 2-component deconvolution technique.

Results: We measured ^{3,4}He, ^{20,21,22}Ne, and ^{36,38,40}Ar concentrations in 32 samples from 10 JaH 073 strewnfield fragments and also analyzed 7 samples from the main mass. Duplicate measurements always give reproducible results, i.e., within the experimental uncertainties. However, for some samples Ar show slightly more scatter than He and Ne, possibly due to the rather large trapped correction. For samples where two or more aliquots have been analyzed average values are used for further discussion. The given uncertainties are then the standard deviations of the means.

Figure 1 shows cosmogenic ^{21}Ne as a function of cosmogenic ^{38}Ar. The good correlation clearly demonstrates the reliability of our deconvolution procedure, which obviously enables the determination of cosmogenic ^{38}Ar despite the huge trapped component.

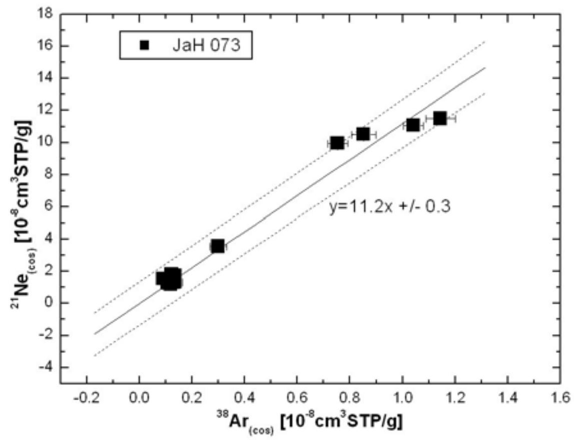

Figure 1: Cosmogenic ^{21}Ne as a function of cosmogenic ^{38}Ar. The linear correlation confirms our deconvolution technique and demonstrates that, despite of the huge trapped component, reliable cosmogenic ^{38}Ar signals can be obtained. Surprisingly our data indicate a production rate ratio P(^{21}Ne)/P(^{38}Ar) of about 11, which is significantly higher than values of around 8 found in literature [4].

Surprisingly, our data indicate a production rate ratio P(^{21}Ne)/P(^{38}Ar) of about 11, which is significantly higher than the ratio of about 8 given in, e.g., [4]. We attribute the obviously too high ratio as due to cosmogenic ^{38}Ar losses. Such Ar losses might be due to the large degree of terrestrial weathering. For example, assuming that ^{38}Ar is equally produced in silicate and metal fractions and assuming further that ^{38}Ar might get lost from the metal during weathering, i.e. during oxidation, results in a slope cc(^{21}Ne)/cc(^{38}Ar) of about 16, i.e., close to the observed value. Our data therefore indicate that cosmogenic ^{38}Ar might get lost from the metal during terrestrial weathering, i.e. during oxidation of the metal.

The large spread in ^{21}Ne for samples with the same (or very similar) ^{22}Ne/^{21}Ne gives a first indication of a complex exposure history for JaH 073. This is confirmed by preliminary radionuclide data. Figure 2 shows the ^{21}Ne/^{10}Be ratio vs. the ^{10}Be amount. The data clearly indicate a bimodal distribution. While some ratios, those having recorded only the second (4π) exposure stage, have an average ratio of 30±3 (atoms/atoms), which corresponds to an exposure age of about 8 Ma, some sample have distinctly higher ratios, indicating a first stage exposure possibly on the asteroid parent body.

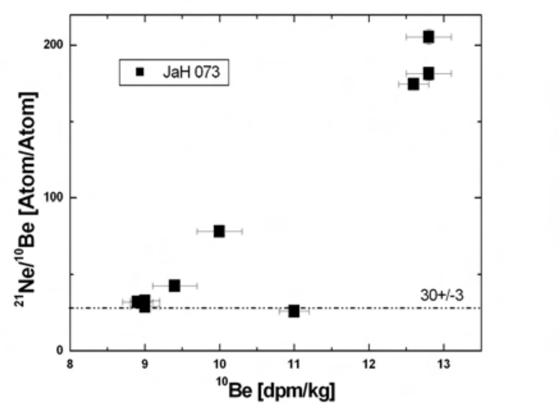

Figure 2: $^{21}Ne/^{10}Be$ vs. ^{10}Be for JaH 073 fragments. The data follow a bimodal distribution and therefore indicate a complex exposure history with a second stage exposure age (4π) of about 8 Myrs.

As mentioned before, the Ar data are compromised by a large trapped component, which cannot be released at 80°C (our pre-heating procedure) and which is most probably due to terrestrial weathering. In order to circumvent this problem we performed 4 step-wise heating experiments to better separate trapped and cosmogenic components. The results are shown in Figure 3.

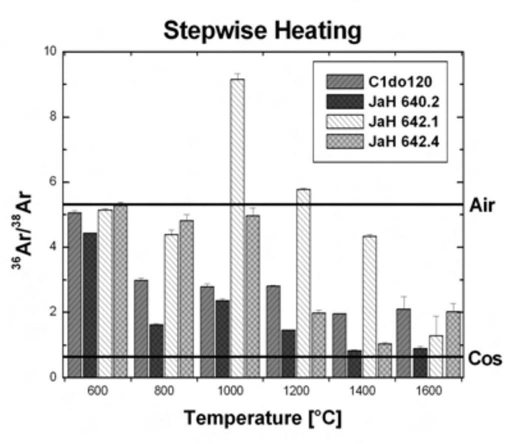

Figure 3: Results from 4 step-wise heating experiments. For each experiment 7 heating steps were performed whereas the seventh step had blank values and is not plotted. The data clearly demonstrate that atmospheric contamination is released dominantly below 800°C, while cosmogenic Ar is mostly released above 1000°C The $^{36}Ar/^{38}Ar$ ratios at 1000°C are higher than at 800°C and 1200°C, possibly indicating the existence of n-capture produced ^{36}Ar.

The data indicate that the majority of the trapped component (released at rather low temperatures) is clearly of atmospheric origin. However, at about 1000°C, i.e., after the release of most of the atmospheric contamination, we measured $^{36}Ar/^{38}Ar$ ratios significantly higher than in the lower (600°C – 800°C) and higher temperature steps (1200°C – 1750°C). We interpret this finding as due to the presence of neutron capture produced ^{36}Ar. Most intriguing is the result from sample JaH 642.1, which gave a $^{36}Ar/^{38}Ar$ ratio of >9. Unfortunately this high value could not be reproduced (aliquot 642.4). However, by combining all data we can conclude that the major part of the atmospheric contamination is released at temperatures below 800-1000°C. In contrast, spallogenic Ar is mainly released at higher temperatures (above 1000-1200°C). Interestingly, it seems that n-capture produced ^{36}Ar is dominantly released at about 1000°C. However, explaining this observation is not straightforward and further work is needed. The finding of n-capture produced nuclides is confirmed by preliminary results of the radionuclide ^{41}-Ca.

Future work: We will determine the cosmic-ray exposure age of JaH 073 using the ^{81}Kr-Kr dating method, and, by combining all data we will not only be able to better constrain the exposure history of JaH 073 but also to better understand the fate of cosmogenic noble gases in highly weathered meteorites.

Finally, the study of large meteorites will be combined with dynamical model calculations of the solar system. It seems that many large chondrites really were exposed on the surface of the parent bodies before being ejected into space. Interestingly, surface studies of the asteroid 433 Eros revealed an abundance of boulders in the 2-10 m size range, i.e., similar to the size of the studied chondrites [5]. While the exposure age studies indicate that the presence of such boulders is very common and that they have survived near the surface over timescales on the order of ~100 Ma, their fate during large collisions has never been tested using dynamical model calculations.

Acknowledgements: This work is supported by the Swiss National Science Foundation. We thank the Omani government for supporting the sampling campaign.

References: [1] Welten et al. (2003) *MAPS 38*, 157-173. [2] Gnos et al *MAPS* (submitted) [3] Huber et al *MAPS* (work in progress). [4] Eugster et al. (1988) *Geochimica et Cosmochimica Acta 52:*1649-1662, [5] McCoy et al. (2001) *MAPS 36*, 1661-1672